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3-1-2005

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Abstract

Radio frequency identification (RFID) tags will likely replace barcodes in the future, and will provide additional security for items. Barcodes allow items to be tracked only at the sku level, while RFID tags allow tracking to the individual item level. This would allow manufacturers, distribution centers, and retailers much tighter control over inventory, and would also help prevent counterfeiting. While this is a positive advance in tracking technology, privacy concerns also abound. Customer concerns over invasion of privacy caused by the ability to track individual items is one problem with the expansion of this new technology. This paper describes the current technology and some current usage of this budding technology. It also explores issues related to privacy, along with both the positives and negatives in the adoption of this technology.

Why RFID??

In June of 2003, Wal-Mart CIO Linda Dillman announced that the retailer would require its top 100 suppliers to use radio frequency identification (RFID), also known as auto-ID, by January of 2005. In addition to Wal-Mart, the Department of Defense (DOD) has mandated its largest suppliers use RFID tags on shipping pallets and crates in early 2005. Like Wal-Mart, the Pentagon would have liked to have all suppliers using RFID by January 2006; this date, however, has been pushed back. Having been around since WWII, RFID is not a new technology. It has been used to track diverse objects such as livestock and cargo on freight trains; it has also been used to track ocean containers and automobiles on toll roads to allow for automatic payment.

RFID Tags vs. Bar Codes

Simply put, RFID is a wireless "communication" method between machines or objects. It is similar to the bar code technology introduced in the early 1970's and currently being used. There are three components: tags or chips (analogous to the bar-code itself) containing an integrated circuit and an antenna connected to that chip; readers (similar to the scanners that read the bar codes) that may be portable or stationary; and software that moves the information from the reader to a database. The reader sends out a small field of electrostatic energy that the chips use to return a signal to the reader.

RFID is different from the bar code in that bar codes allow for tracking items only at the sku (item number) level while RFID tags allow for tracking items at the unit level. Barcodes must be read one at a time and require line of sight. Although RFID does not work through metal, liquids or thick barriers, line of sight is not required. RFID chips can be molded into a product's casing, making it invisible to the consumer. RFID readers must be close enough to the tags to pick up the signals. Although the RFID technology that Wal-Mart is requiring of their suppliers has a range of approximately 15 feet, the range of RFID tags can vary. The longer the distance between the chip and the reader, the larger and more expensive the chip must be. Today's tags that could be read from a greater distance would not be practical on most packaged consumer products. However, the technology is rapidly evolving; stronger, smaller chips are constantly being developed.

UPC vs. EPC

A numbering system, similar to Universal Product Codes (UPC's) was developed by MIT's Auto-ID Center. This numbering system is known as "Electronic Product Code", EPC. Literally trillions of number combinations are possible. The code uses 96 bits of information: 8 bits of header; 2 sets of 24 bits each from manufacturer and indicating product type; and 40 bits for a serial number. The European Union's Uniform Code Council was also working on a type of EPC protocol. In late 2003, the two groups formed a joint venture, EPCglobal, which is working with early adopters to set code standards. A problem is that DOD needs to use the International Standards Organization (ISO)'s specifications that are slightly different from EPCglobal's specifications (Brewin, 2003). DOD wants a data storage capacity that exceeds EPCglobal's 96 bits. Doubtless, the system that evolves will be able to read either type of chip similar to the ways that early versions of software can be read by later versions.

How the Computer "System" Works

The value of RFID is realized when the EPC is coupled with databases. These databases can be housed on any number of computers. The EPC is the unique identifier used in each database. EPCglobal's protocol uses an Object Name Service (ONS) that tells a system where to look for information on a given EPC. This is similar to web pages using IP addresses to retrieve information. ONS is based partly on the currently used DNS (domain name service) and will allow the trillions of transactions that are expected to take place easily (CoverPages, 2001). The information itself will have a new language, Physical Markup Language, PML, to describe the attributes of the object. Again using an Internet analogy, just as HTML, hypertext markup language, describes how a web page should be displayed and how it looks, PML describes the physical attributes of an item. PML is designed to work with RFID technology. This language was created specifically for this purpose, and was designed as an XML-language to facilitate the cataloguing of physical items. These languages allow customized tags to allow data to be transferred between applications and organizations. PML is a standard language to be used when describing objects. Though physical objects have many differences, there are a few standards which have been used in PML to make the process of classifying objects simpler (CoverPages, 2001). It is envisioned that information on a given EPC will reside on several computers (i.e. manufacturer's supplier's, the manufacturer's computer, and the retailer's computer).

Benefits Of Adoption

In addition to Wal-Mart, Proctor & Gamble and Gillette are two companies which have invested early and heavily in RFID technology. While the cost of the RFID tags is still very high compared to current bar codes, the companies hope to save money by reducing counterfeiting, reducing shrinkage or theft, and by increasing supply chain visibility (Kinsella, 2003). The reduction in costs would help to defray the expense of the new technology. A very different type of organization, the European Bank, is also looking at embedded RFID chips to deter counterfeiting of the Euro bank note ("Anchorage, Alaska Based-Firm," 2003).

Theft has been estimated to account for two percent of revenue for consumer goods. Fifty-five percent of that theft occurs before the goods reach retailers, in the supply chain. While there has been much attention to shrinkage at the store level (hidden cameras, Sensormatics, etc.) little has been done to address the problem within the supply chain. The use of RFID allows for better tracking of inventory and aides in determining the point at which the loss occurs. Losses are detected sooner, making it easier to find the thief. Future theft is deterred. As an example, a reader could be placed on a truck. The information could be accessed remotely, allowing the dispatcher to know when certain cases were no longer on the truck. Coupling that with global positioning satellite (GPS) technology, it would be possible to know exactly where the cases were taken off the truck.

There are supply chain benefits. Cost reductions have been estimated by A.T. Kearney to be a 7.5% reduction in warehouse and store labor cost; a reduction in stock out lost sales leading to a 0.07% increase in sales; a one-time cash savings equal to 5% of their inventory (Quinn, 2002). Better supply chain visibility leads to faster replenishment, reducing the cost of lost sales due to out of stock situations. There is less need for safety stock. Less inventory is required within the supply chain as a whole. This can lead to fewer trans-shipments, less material handling and can help reduce the accumulation of slow moving or obsolete inventory.

Information captured can include information on shipping and receiving, expiration dates, or batch numbers (Schnmidt, 2001). For drug manufacturers or food processors, this batch information can lead to better recall procedures. When used with loyalty cards, you can track the product to the consumer.

Drawbacks To Adoption

Perhaps the biggest drawback to using RFID is the cost of implementation. Although cost estimates vary widely, everyone agrees that the cost will be high, in the hundreds of thousands of dollars, and the majority of the costs will be born by the manufacturers and suppliers ("RFID Costs", 2004).

The cost of the tag itself is currently a problem. Bar codes cost about $.001 each (Kinsella, 2003). RFID tags cost about $.015, making it rather expensive to add a tag to every unit produced. Read-write tags, which can add information at different times during the life of the product, cost more than read-only tags. The further away the reader will be from the tag (meaning a stronger signal is required), the more expensive the tag. Readers, too, vary in price depending on speed and signal strength (Dunlap, et al., 2003). Other costs include software, and programming to integrate RFID with other institutional software. In addition, there appears to be a steep learning curve for adoption of the new technology (Kinsella, 2003). In a February 2003 report, IBM Consulting Services reported that at a recent RFID Forum, early adopters reported spending more than $500,000 to get to pilot-project stage (Gramling, et al., 2003).

Another potential drawback to adoption of RFID technology is the database issue. In order to house the vast amounts of data that will be assigned to each individual item and collected from each individual item, there must be a repository for this information. The database needs will be very large to store information on the trillions of items which have a tag attached. Manufacturers will need to make decisions about the length of time to keep each record. This would require different amounts of space for some items than others. Any item which will be consumed by people could be tracked more efficiently in case of recalls, but different items have vastly different shelf lives. Canned items generally have an expiration date several months to a year beyond the date of packaging. Meats, fresh fruits and vegetables have considerably shorter shelf lives, while some items like noodles might last for several years. What cutoff will companies use for maintaining the data? Will it be stored in the manufacturer's database until the product is sold? Until the product expires? Until the product shows up in a landfill? Or perhaps the information will not be removed at all.

Privacy Concerns

There exist numerous concerns over privacy regarding RFID technology. Who actually owns the data stored in these tags and transmitted to myriad databases? Manufacturers, warehouse/distribution centers, retailers, consumers? All have some claim to the data. Manufacturers could use the data for recalls, as well as for forecasting demand more accurately to certain demographics. Distribution centers and retailers would also be interested in the data demographically, while consumers fear this very use of the data. Plans for RFID tags to follow a specific product through its entire lifecycle, from manufacture to households to recycling, may be stifled by strong opposition from privacy advocates. Education of the public will be key to acceptance, and public choice as to participation will likely be required. A proposal that tags be disabled before leaving the store may allay some of consumers' fears. The idea of data from the databases being used "against" them will still likely require some promises from those owning the databases.

At this time, RFID tags used in most inexpensive products are not sophisticated enough for their data to be read at great distances, but technology is improving constantly. Savvy marketing companies could send market researchers to scan certain neighborhoods in the future, as opposed to lurking in parking lots to count customers or doing endless direct marketing calls and flyers. While these methods are undeniably more cost effective at the marketing level, the consumers' feelings of invasion of privacy are ever increasing.

Marketers are not the only ones likely to take advantage of the availability of information at the consumer level. While manufacturers are educating the public about the location of the tags, mostly in the packaging, thieves may also be taking note. As packaging is discarded, a blinking beacon issues an invitation to remove big ticket items from homes which recently added them.

Uses

Delta Airlines implemented a pilot project using RFID tags in their baggage handling operations (Brewin, 2003b). They improved baggage handling accuracy from 80-85% to 96.7-99.9% by using RFID equipment in their system. Changing from UPC readers to RFID readers was the only major system change or training of check-in agents required.

RFID is being used to improve efficiency at west coast ports (Mongelluzzo, 2003). Powerful chips are attached to the tractors picking up containers. As the tractors enter the shipping yards, information about the tractor license and the trucking company is entered into the terminals operating system. Although no information is being captured about the container itself or the cargo, the small change has improved efficiency and turnaround times at ports by automating a single process.

A new shopping experience may also be possible. So-called "smart shelves" can notify the stockroom when only a few items remain on the retail shelf. Consumers, using hand-held computers or PDAs might be able to activate a shelf tag, thereby

retrieving data base information about the product, it's use, contents, etc. (Schnmidt, 2001). Consumers could read drug reaction warnings for over the counter medications, find recipe suggestions for food items, access product compatibility lists for oil filters, or get gardening tips while shopping for potting soil. Many people enjoy the ability to add to their shopping experience, and would gladly bring along a hand-held computer or PDA in order to retrieve this additional information.

RFID chips appear in many car keys on late model vehicles. Select General Motors vehicles used RFID chips in their keys from about 1994 to 2000. General Motors vehicles with RFID chips were usually the more expensive models, and this was used for security. Without the correct key, the vehicle would not start. That system evolved to a system where a resistor was placed in the key, but the problems with damage to the key led to the use of a system where the resistor is placed in the switch instead of in the key (Personal conversation, Duke Green, November 8, 2004). Ford trucks as early 1996 were using RFID technology in their keys. The receiver is in the steering column and the chip is located in the key. Most Ford vehicles now have this system in place. (Personal conversation, Bill Houston, November 8, 2004).

Conclusion

RFID technology has a place in the future. Predictions are that RFID tags will replace barcodes; the main question to be pondered on that prediction is the timing of that replacement. Many issues remain to be determined with regard to the technology. Adoption timing will be controlled to some extent by demands of customers. How the technology is used and to what extent items will be tracked will be determined by customers and some form of regulation may be forced. Standardization is certainly needed, and many may wait to adopt until standards are in place. Using available technology to our advantage is certainly important, but monitoring and controlling that technology to protect rights is also an aspect of advancement. How RFID technology is accepted will be determined by how it is presented, and how privacy is protected.

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